# A System for Automatic Surveillance Aid on Maritime Search and Rescue by Optical Sensors

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## 1. INTRODUCTION

In order to transmit and receive accident information, Japan introduced GMDSS (Global Maritime Distress and Safety System) in February 1999. And, a victim on the sea can be quickly rescued now by this GMDSS and EPIRB (Emergency Position Indicating Radio Beacon). The persons in charge of a search, however, have to assume many situations. Then, also in the situation that the function of GMDSS does not operated, the rescue activity must be performed quickly and effectively.

Now, the work of the maritime search is carried out by the surveillance from the airplane and the patrol boat of the Maritime Safety Agency. For example, when the small life raft is set as a search target, it is enabled to search large ocean space quickly and efficiently by using an airplane. However, it is also a fact that the discovery of a small non-conductive target by viewing and radar under the severe natural environment condition is very difficult work.

"Under favorable condition an average observer can maintain good visual efficiency for about two hours." It has written to "ISO SEARCH AND RESCUE NANUAL". With a natural thing , the physiological Limit as a human being is in an observation member. Therefore, it is asked for development of the new system to complement the negative factor as such a human function in the work of maritime surveillance.

## 2. OUTLINE OF SURVEILLANS AID SYSTEM

The concept of the system is shown in Fig.1. As the main input information to the system, the environment information such as the weather and the sea state, the position information such as the latitude longitude by GPS, the flight altitude, and the data observed by Image sensors are set up. In basic specification, this system was planed as a system with multichannel image data using two or more sensors. And two sensors, a visible ray video camera and an infrared video camera, are adopted in the present system. On the other hand, the multimedia information to aid the boarding observation members in the surveillance work are outputted.

This system consists of two image sensors, the control devices, the monitors, the VTR, the computers and

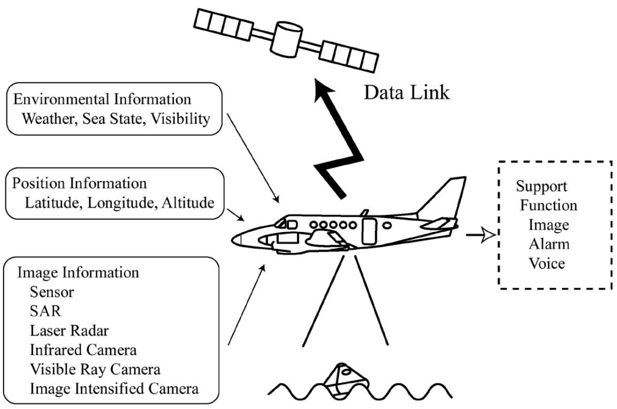



**Fig.1 Concept of Surveillance Aid System**

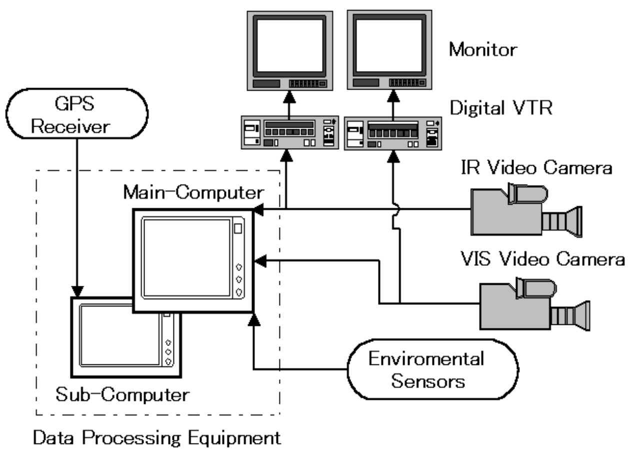



**Fig.2 Principle of Surveillance Aid System**

GPS receiver, as shown in Fig. 2. Photo 1 shows the actual loading situation to the experiment airplane and the arrangement situation.

The adopted infrared (IR) video camera detects 3-5 μm infrared by 800*512 pixels and the color video camera is the 3(RGB)-CCD visible ray (VIS) video camera. Observed images are recorded by the digital video recorders which can record RGB separately. The personal computer (PC) is used to capture images (IR and VIS image) and process them. The PC arranges 2 single board-computer (SBC) to one case. One of two SBC carries out the image capture and processing, and another SBC carries out the display of a detection result for the surveillance aid.

Although the purpose of the maritime surveillance aid system is a performance of automatic surveillance work and aid, this system is never a full automatic system without a human being. Even if full automation will be possible, the cooperation work of a computer and a human being is required. It is considered necessary to connect closely a human's wisdom and computer technology by the high level human-interface on the maritime surveillance.

The flow chart of the data processing in PC was shown in Fig.3. The data for image processing are IR and VIS images sampled with the main PC according to the basic interval setting. In this system, the main PC carries out continuous execution of the image capturing and processing at the basic intervals of 1 second. The result of data processing in the main PC is communicated to the sub PC and the aid for the maritime surveillance was realized by a information display, an alarm and a warning voice in the sub PC. However, the sub PC is usually working on the route plotting by GPS, etc.

## 3. TARGET DETECTION AND IMAGE PROCESSING

As shown in Fig.3, three algorithms for the target detection are prepared in the present system and these algorithms have been processing IR and VIS image data. The outline of each detection algorithm is shown below.

(1) Thresholding using RGB combination of target color
(2) Distance judging in RGB color coordinate system
(3) Pattern recognition of target image

The algorithm (1) and (2) uses the VIS image data, and

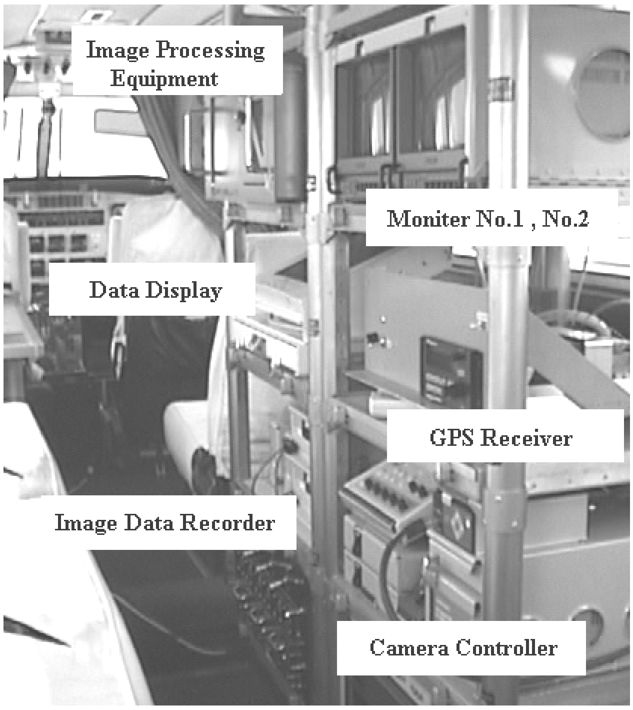



**Photo 1. Loading Situation in Airplane**

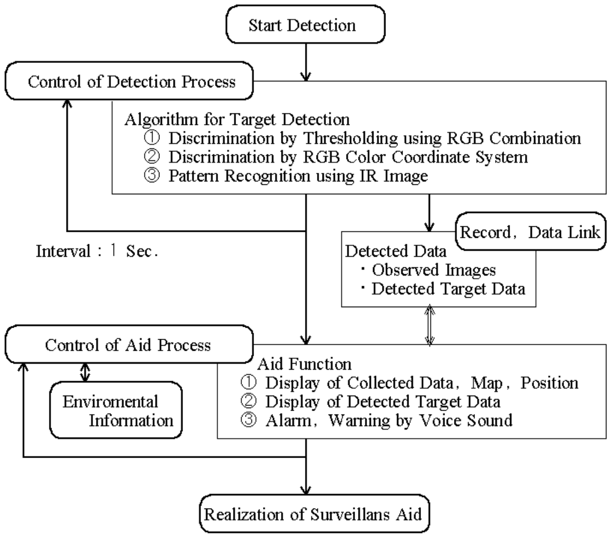



**Fig.3. Flow Chart of System Action**

the algorithm (3) uses the IR data for the image processing to detect a target object.

A major target for this system is the life raft and the life raft to detect is coloring the characteristic orange of a legal color. On this characteristic color of the life raft, the algorithm (1) determines the threshold level and execute the image processing.

Photo 2 shows the actual life raft which has been using for the experiment. This life raft (TRA-6A: the diameter of 2.4m, height of 1.4m) is 6 person ringing.

Fig.4 shows the cumulative number of pixels for the brightness of the sea surface and Fig.5 shows the cumulative number of pixels for the brightness of the life raft canopy. It is clear that there is a difference between them, and its difference is more clear in R-factor brightness. The threshold level is determined by using the mixture ratio of each R-G-B brightness. That is, the thresholding in the algorithm (1) is based on the RGB combination. The threshold level (t) is shown below.

Life Raft ; $2 * Fred / ( Fgreen + Fblue ) \geqq t$

Fred : R brightness on a pixel

Fgreen : G brightness on a pixel

Fblue : B brightness on a pixel

This threshold level based on the RGB combination estimate the color characteristic of pixel in the target as non-dimensional index.

Fig.6 shows the pixel brightness of the observed image containing the sea surface and the life raft in the RGB color coordinate system. The algorithm (2) determines the characteristic on every pixel using the distance judging in the coordinate system of RGB color. And, the pixel which is not the sea is chosen as the pixel formed the life raft.

The algorithm (1) and (2) are the method to apply in the VIS image data. Because the VIS image data is 3 channels (RGB) data, it is very important data and the information in this system. However, the VIS camera does not work in the night and the environment without a view. In this point, it is necessary to provide another sensor to use under the non-view condition. Since the IR camera is able to perceive the thermal radiation of a object, it can also be used in the night without a light.

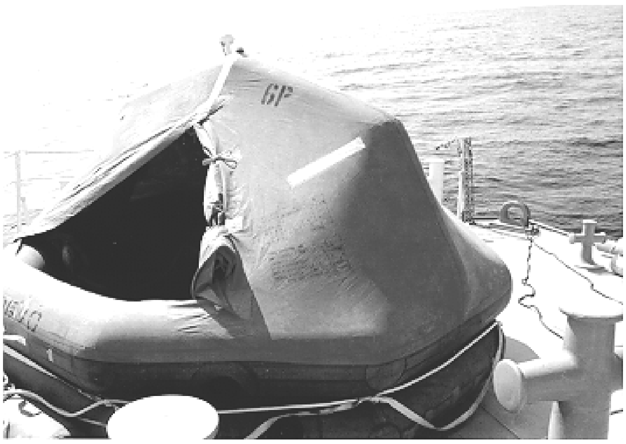



**Photo 2 Life raft**

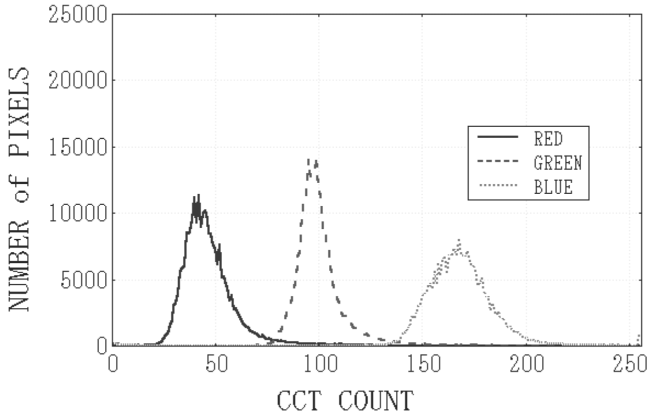



**Fig.4 RGB Brightness of Sea Surface**

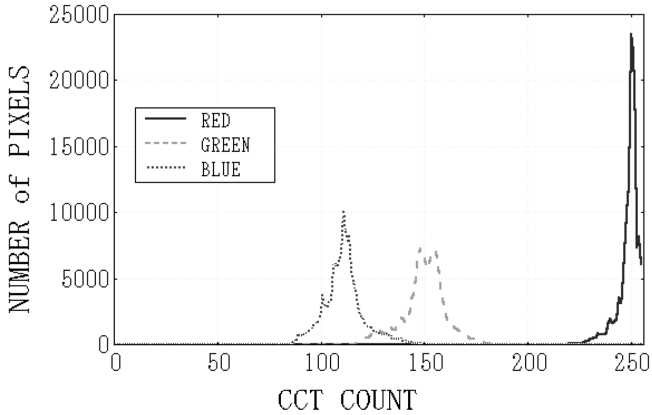
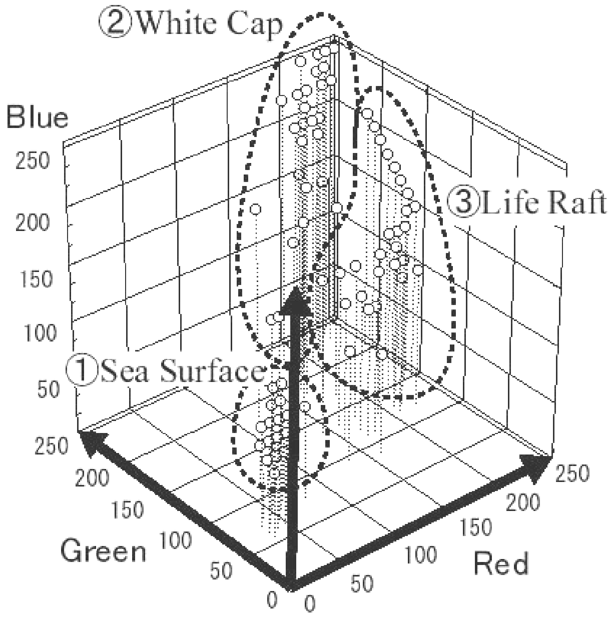



**Fig.5 RGB Brightness of Raft Canopy**

**Fig.6 RGB Brightness of Sea Image**



The example of actual infrared image is shown Fig.7. This IR image is observed form flight altitude 6500ft.. This image is very clear and the IR reflection of the target is also clear in the 3-dimentinal indication. However, the target is often buried under the noises such as solar reflection. Therefore, these noise reduction techniques had been a main subject but it has been already confirmed that the use of low-cut optical filter is quite effective for noise reduction in IR image data. The pattern recognition of the target image is carried out using the intensity and the form of the infrared image data.

## 4. FLIGHT EXPERIMENT

The flight experiments for the functional estimation of the system was conducted a total 3 times. At the last experiment in September 1998, the operation of all equipment and the surveillance aid were fully proved.

The situation of an experiment on board shows in Photo 3. The target life raft was left on the sea and moored to the patrol boat to support the experiment. And, the experimental aircraft which had been loaded the surveillance aid system flew over the life raft in different flight altitudes and directions.

Fig. 8 shows the observed image by VIS video camera as an example. This flight altitude was about 3500ft.. The target life raft is checked at the lower left of the patrol boat in this image. The target image is very small but its reflection is clear enough to execute the algorithms for the detection. Therefore, both of the algorithms for the VIS image were able to apply and the result of the image processing shows in Fig.9. When the information of the target is gotten, the system could carry out the surveillance aid at once. In the last experiment, every step of the system action was confirmed.

It is very important factor in the maritime surveillance aid system that an observation member is able to get the information of the sea quickly and certainly. The ability of the real time processing have to maintain all the time in hard/software and the superior human-interface to communicate the information has to be equipped in the system. These factors could realize the useful system for maritime surveillance aid.

In the last experiment, the aid function is carried out by the display shows in Fig. 10. This display shows the flight rout plan, the present position, the sea chat, the information of target and the observed images, etc.

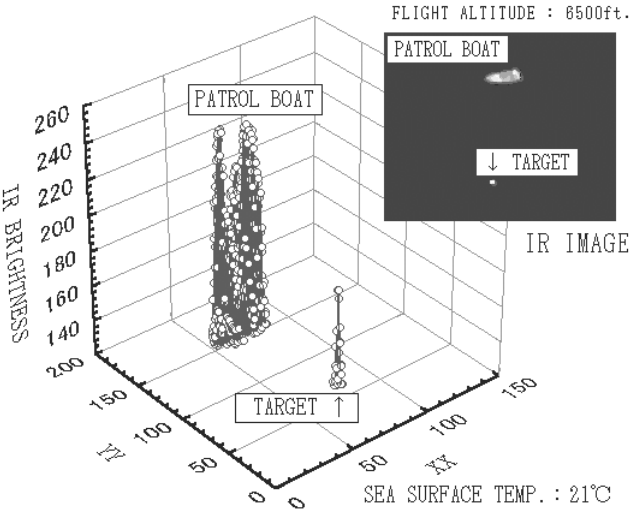



**Fig.7 Intensity of IR image data**

**Photo 3 Situation of Experiment on Board**

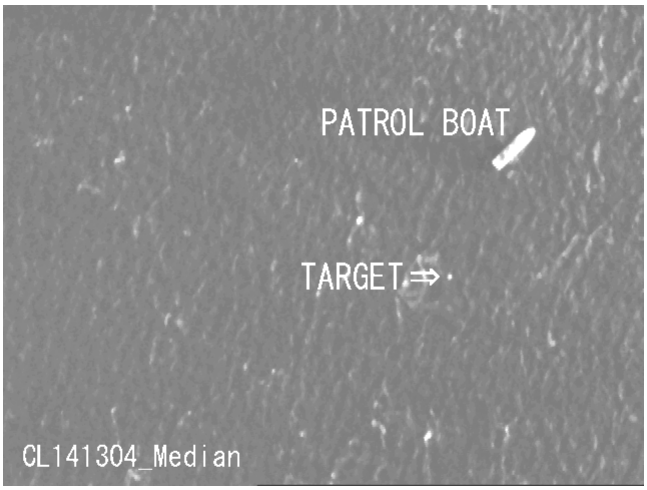



**Fig.8 Observed VIS image (3500ft.)**

The relation between the detected life raft image data and the flight altitude is shown in Fig.11. It is presumed from these relations that the limit observation altitude is about 7200ft. in this environmental condition.

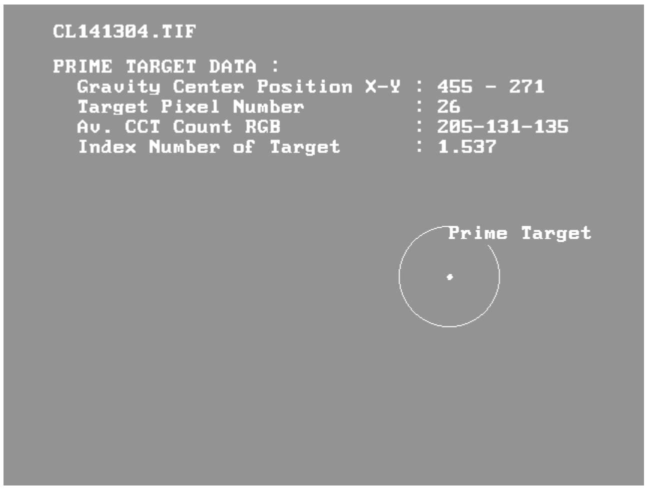



**Fig. 9 Result of Target Detection**

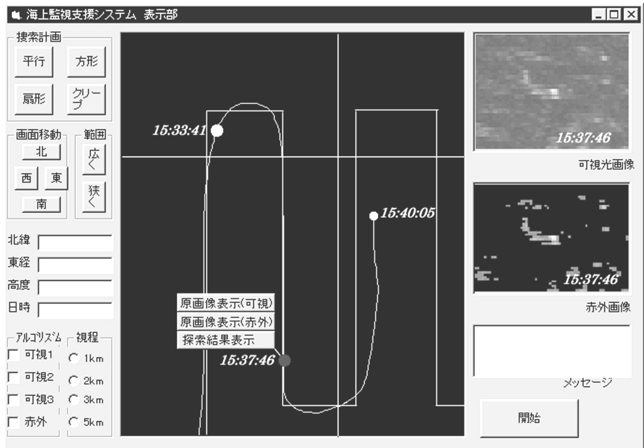



**Fig.10 Display for Surveillance Aid**

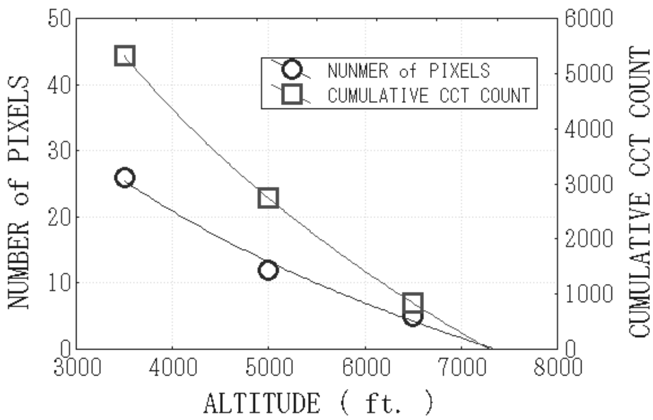



**Fig.11 Relation Between Detected Life Raft Image and observation altitude**

## 5. CONCLUSION

This maritime surveillance aid system was designed a system to detect automatically a life raft on the sea. Some of this type system and equipment have been examined but many of them have still some problems to civil practical use. Therefore, it is very important point that this system could use as a civil practical equipment.

This system could have realized the technique of the small target detection, the noise reduction and the display of aid information on the real-time processing. And, these functions were confirmed in the flight experiments. At the final experiment, the total processing time was about 0.8 seconds and the appropriate altitude to the maritime surveillance is about 5500ft. in this system.

Since it is clear that the technique of hard/software in the computer technology makes progress every year, the new system for the maritime surveillance aid also will be developed. In the computer system, the relationship with a human being is an important subject. Therefore, the design of the human-interface is important.

The flight experiments were executed by the special efforts of the Maritime Safety Agency. It is a pleasure to acknowledge the cooperation of the persons concerned.

## 6. REFERENCES

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